Scope and limitations

By shifting the power load from day to night exergy storage systems can make radical changes in the national pattern of energy use. However, that raises the question of whether there will be sufficient power available to run the exergy-boosting heat pumps. The following are the recent energy consumption figures for Canada and some of the Provinces: (2010 Residential data from OEE, NRCan)

	Space+water heating	**Electricity**
Canada	1089 PJ	530 PJ
Ontario	410	120
Atlantic	89	49
Quebec	234	216
Manitoba	34	28
Saskatchewan	42	12
Alberta	85	38
British Columbia	109	67

In Canada as a whole 217 PJ of the electricity consumption is being used for space and water heating (25.4% of the total). For those residences there will be a large reduction in the power consumption because the energy is being extracted from the air or comes from the solar thermal collectors. The amount of this reduction depends on many factors so to proceed with this analysis let us assume that for the residences that presently use electricity for heating the electricity consumption is reduced to one third of the present value, or 72 PJ, with virtually all of it occurring during the night. The remaining 872 PJ of thermal energy will require 291 PJ of electricity to drive the exergy store, again at night. That brings the electricity consumption total to 363 PJ for space heating+water. The amount of electricity being used for non-heating applications is 313 PJ (mostly during the day), bringing the total electricity consumption to 676 PJ, an increase of 28% over current residential electricity consumption.

The emerging residential pattern of use would be very roughly that 313 PJ of electricity would be used during the day and 363 PJ would be be used at night, thus over-correcting the present strong day/night load imbalance. The next step in this evaluation will be to carry out a similar review of the energy consumption of commercial and institutional buildings. Large buildings primarily need to get rid of heat so presently they have large day-time electrical loads to run their air conditioning and relatively smaller annual heating loads. The total Canadian energy consumption of commercial and institutional buildings is 1057 PJ (for 2010). 56 PJ of that total is presently used for electricity for space cooling, so eliminating that consumption will partly compensate for the 146 PJ increase in total electricity demand for residences. Large buildings also use relatively smaller amounts of energy for space and water heating so it is likely that the over-correction in day/night usage referred to above will be ironed out when commercial/institutional buildings are included. After adjusting for other factors like the reduction in transmission losses and the ability of exergy storage systems to store the energy from intermittent sources like wind turbines it appears that electricity supply is not likely to present an obstruction to the replacement of fossil fuels by air and solar heat.

Switching to exergy storage would reduce the annual GHG emissions from space heating+water by 54 Mt (CO_2 equivalent) and would at the same time balance the day/night loads, relieving many of the existing supply and distribution problems. Canada's reliance on fossil fuels for heating+water could theoretically be reduced to zero, and the 28 Mt(e) emissions from power generators could likewise be reduced or eliminated. While there remains much to be done to complete the analysis the picture that is emerging is that the switch could be accomplished without straining the electricity supply resources (see the June issue of Sustainability-Journal.ca for reviews of the provincial supply options).

There other alternatives that might theoretically be used instead of exergy storage. For example, nuclear power stations might provide enough power to meet the normal electrical needs plus the energy needed for heating and hot water. However, for Canada that would mean increasing the electricity supply capacity from 530 PJ per year to 1619 PJ per year, providing the system with enough peak power capacity to handle the corresponding peak power loads, which would be enormous, and designing the supply and distribution systems so that they could economically cope with huge seasonal and daily fluctuations. Intermittent energy sources like wind turbines and solar PV panels are useful where they are being used as small power contributors to the grid but in addition to having to cope with the large demand fluctuations they would also need to handle their own supply fluctuations so they are not attractive as primary energy sources. Any solution to the GHG challenge will need to be both technically and economically feasible and must achieve its ultimate objective by about the year 2050 without needing to completely rebuild our building stock. Exergy storage may be the only option that could actually satisfy those requirements.

Incentives

Maybe if last week's flood in Calgary were an annual event there might be enough incentive to take substantive action but clearly the mere threat of impending climate change is not enough, even though that threat is very well documented by scientific evidence.

A more effective incentive would be an energy supply alternative that is both capable of providing a real solution, even if only in the buildings sector, and that is also cheaper than fossil fuels. There is one way in which that might be accomplished.

Storage provides a cheaper way of balancing electricity supply and demand than the current practice of building up the generation capacity so that it can meet the peak loads. The savings would amount to tens of billions of dollars for each of the larger Provincial grids. If the power companies were to build the exergy storage facilities then the cost of building those stores (which are little more than 13 holes bored in the ground but which represent a large up-front cost to the building owners) would be much less than the costs presently being incurred in building new gas-fired or nuclear generation stations and in upgrading the power distribution systems in order to handle the load fluctuations. If the power companies build the exergy stores and reap the benefits from utilizing the storage then the need for heating/cooling equipment in the buildings is reduced to providing just the hot water system. The consequence is that the building owners will also realize immediate benefits in terms of both capital and operating cost reductions, plus an eventual benefit in terms of lower electricity prices in the future. The result is thus a win-win solution for both parties and a huge win for the environment at the same time. If there is no such cost-splitting agreement then there is very little incentive for the building owners to incur the cost of building the stores. What is needed are strong incentives for both parties if we are to have a solution that can be implemented within a few decades.

Such a solution is not automatically a self-starter. The power organizations have a big investment in their existing technologies and they are mostly owned or controlled by governments that have vested interests in the status quo and the fossil fuel industry, with which they are virtual partners. When a senior official of the Ontario Power Authority was asked in a public forum if the OPA would be willing to discuss such a solution (which had previously been explained to him) his response was "No", curtly observing that the OPA was not interested in heating buildings. However, it is the consumers who are being subjected to practices that are presently damaging to both our environment and our economy. If we want this (or any other) solution to be considered by the OPA, OPG, OEB, NEB or any of the other organizations that profess to represent the public interest then we will have to demand that they take a more open minded and professional approach.